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Consumption behaviors and cognitive flexibility in families of adolescents with anorexia nervosa

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Résumé

L'anorexie mentale (AN) est le trouble psychiatrique avec le plus haut taux de mortalité, qui peut être maintenu par des difficultés cognitives comme le manque de flexibilité cognitive. La thérapie de remédiation cognitive (CRT) comme complément à la thérapie familiale (FBT) permettrait d'augmenter la flexibilité cognitive des parents et de leur adolescent, mais son impact comportemental reste incertain. Cette étude exploratoire examine le lien entre la CRT et les comportements de consommation : la sélection de produits d'épicerie. Les 40 participants de 12 à 18 ans atteints d'anorexie ont été recrutés avec leur famille pour un projet créé par une équipe du Children's Hospital of Philadelphia. Ils ont été répartis aléatoirement en trois groupes : FBT seule, FBT avec CRT pour les parents (CRTp) ou avec CRT pour adolescents (CRTa). Les choix alimentaires parentaux ont été analysés à T1-baseline, T4-13 à 15 semaines et T5-fin du traitement dans l'épicerie en ligne expérimentale OSOG. En moyenne, les participants ont choisi des produits contenant plus de calories à T5 qu'à T1. Aucune différence significative n'est observée entre CRTp et le groupe contrôle à T5. Les produits du groupe CRTa à T5 contiennent moins de sucre, contrairement aux deux autres, et de glucides en comparaison au groupe contrôle. Ces résultats suggèrent que le traitement de flexibilité cognitive individuelle n'aurait pas de lien simple avec les comportements de consommation. Il serait pertinent d'explorer l'impact combiné des CRTa et CRTp avec un échantillon plus large pour évaluer l'interaction parent-enfant de la flexibilité cognitive sur les comportements alimentaires.

Mots clés : Thérapie de remédiation cognitive, alimentation, thérapie familiale, épicerie

Méthodes de recherche : Expérimentation, recherche quantitative, recherche exploratoire

Abstract

Anorexia Nervosa (AN) is the psychiatric disorder with the highest mortality rate, which can be maintained by cognitive difficulties such as a lack of cognitive flexibility. Cognitive remediation therapy (CRT) as a complement of family-based therapy (FBT) could enhance parents' and their adolescent's cognitive flexibility, but its behavioral impact is uncertain. This exploratory study examines the association between CRT and consumption behaviors: products' selection during grocery shopping. The 40 participants aged between 12 and 18 years old with anorexia nervosa (AN) were recruited with their family for the Shifting-perspective project of the Children's Hospital of Philadelphia. They were randomly assigned to three groups: FBT alone, FBT with CRT for the parents (CRTp) or with CRT for the adolescents (CRTa). The parental food choices were measured at T1 – Baseline, T4 – 13 to 15 weeks and T5 – end of treatment in the online experimental grocery store OSOG. On average, the parents chose products containing more calories at T5 compared to T1. No significant difference was observed between CRTp and control group at T5. Product choices of the CRTa group at T5 contained less sugar, in comparison with the two other groups, and less carbs in comparison with the control group. Those results suggest that treatment for individual cognitive flexibility does not have a simple association with consumer behaviors. It would be interesting to explore the combined impact of CRTa and CRTp with a bigger sample to evaluate parent-children interaction in cognitive flexibility on consumption behaviors.

Keywords: Cognitive remediation therapy, feeding, family-based therapy, grocery shopping

Research methods: Experimentation, Quantitative Research, Exploratory Research

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List of Abbreviations

AN: Anorexia Nervosa

CHOP: Children's Hospital of Philadelphia

CRT: Cognitive Remediation Therapy

CRTa: Cognitive Remediation Therapy for adolescent

CRTp: Cognitive Remediation Therapy for parents

ED: Eating Disorder

EDATP: Eating Disorder Assessment at Treatment Program

FBT: Family-Based Therapy

IBW: Ideal Body Weight

OSOG: Open Science Online Grocery

REB: Research Ethics Board

T1: Treatment phase 1 – Baseline measurement taken before treatment began

T4: Treatment phase 4 – Measurement taken between 13 to 15 weeks after treatment began.

T5: Treatment phase 5 – Measurement at the end of treatment

Preface

Every day, people across our society dedicate themselves to helping others, whether in healthcare, teaching, or the mental health fields. Research serves as a path to building tools that heal, support, and transform lives. It is the stepping stone to imagining better futures – not just for the individuals, but for the systems that shape them.

Marketing is too often cast in the shadow of profit, wrongly associated with the pursuit of money rather than acknowledged for its potential to do good for human beings. This project was born from that conviction – that marketing when used thoughtfully with the right purpose and conscience, can help consumers make more reflective, health-conscious choices. My background in psychology deeply informed this work. Seeing how entangled with cultural, cognitive, and environmental forces are conditions like anorexia nervosa, I've come to believe that interventions should be tested not only in theory but in the rich complexity of the real world. Only then can we begin to understand their effectiveness.

The growing distinction between intentions and behaviors in marketing research is what particularly inspired me to collaborate with the team at CHOP on this project. It is in this gap—between what we plan to do and what we do—that behavioral change takes place, and where psychology and marketing must come together. Those fields are deeply interconnected, and both can gain from sharing their tools and knowledge in service of human well-being.

This thesis is, in many ways, a statement to those who believe that pursuing multiple specialties leads to fragmentation of one's path. I have found the opposite to be true. Bridging together diverse ways of thinking has opened more doors than it has closed, allowing me to ask better questions and seek answers with greater nuance. This research stands as proof that a multidisciplinary lens offers a vantage point for tackling complex questions. This project helped me deepen my understanding of both fields and was a true eye-opener on the vital importance of measuring real-world behavioral change. I will continue to pursue my goal of helping others, carrying forward the lessons this project has given me - as a scientist, and as a person.

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To my parents, my sister, and my brother-in-law — thank you for being endlessly inspiring in your own unique ways, and for pushing me to become the best version of myself every day. You built me this strong, you are what made me the person I am today, but also the reason why I want to do good in this world.

Seeing how my life is filled with incredible and brilliant people is one of the main reasons why giving back means so much to me. I dedicate this thesis to all the professors - from kindergarten to university - who made it their life's mission to share knowledge. Thank you for giving a little girl like me a passion for learning. I hope one day to be as good for at least one person as you were to me.

Introduction

Anorexia nervosa (AN) is a severe and persistent eating disorder (ED) with the highest mortality rate among psychiatric conditions (Costandache et al., 2023; Tchanturia et al., 2017). With only a few effective treatments available, medical and psychological complications contribute to over half of AN-associated deaths (Costandache et al., 2023; Orloff et al., 2023; Tchanturia et al., 2017). A large proportion (10-20 %) of patients with anorexia nervosa onset is during adolescence, with a peak incidence as soon as 15 years old, making treatment of this disease in adolescents critically important (Herpertz-Dahlmann, 2021; Van Eeden et al., 2021).

The standard care approach for adolescents with AN is Family-Based Treatment (FBT). However, even after FBT treatment, a non-negligible number of adolescents recovering from AN continue to face cognitive difficulties that interfere with daily functioning (Egbert et al., 2023; Tchanturia et al., 2017). These cognitive challenges can also prolong the disorder and lead to poorer treatment outcomes (Lock & Le Grange, 2019; Tchanturia et al., 2017). In particular, these adolescents seem to be prone to cognitive inflexibility—difficulty changing between tasks or between ways of thinking, which can make it difficult to shift away from disordered thinking about food, such as focus on control of weight, fixation on weight loss and body distortion image (Duriez et al., 2021). Cognitive (in)flexibility, in addition to being a key factor in AN maintenance, is heritable (Duriez et al., 2021; Timko et al., 2021). As such, those difficulties can be observed in parents and siblings - parents too may struggle to make the cognitive shifts necessary to help with their child's recovery (e.g., making the change to think of high-fat foods, like pizza or cookies, as "healthy" for their child and to push him/her to eat even if it's distressing) (Honey et al., 2008; Schebendach et al., 2019; Timko et al., 2021; Wilksch, 2024). Given that parents are already highly involved in FBT, some researchers have proposed that incorporating an additional intervention targeting cognitive flexibility —Cognitive Remediation Therapy (CRT)— for families might help address the chronic nature of AN (Timko et al., 2021).

This study explores how interventions aimed at improving parental and adolescent cognitive flexibility affect treatment outcomes for AN. Specifically, we are interested in how integrating CRT (parent-focused or adolescent-focused) into FBT could be related to a reduction in adolescents' resistance to treatment and an improvement in parents' ability to adhere to the treatment plan. To assess these variables, we examine the effect of treatment on grocery shopping, which is known to be challenging for families with a child suffering from AN (Koller & Berg, 2021; Makara et al., 2023). Our analysis includes product selection, emphasizing the diversity and micro- and macronutrient content of chosen items.

This work makes several contributions. First, there is a considerate amount of literature on the developmental processes and possible causes of anorexia nervosa, but the disorder is complicated, and the sources remain unclear (Baker et al., 2017; Blank & Latzer, 2004; Heaner & Walsh, 2013; Krug et al., 2015; Lindberg & Hjern, 2003; Paolacci et al., 2020; Pinheiro et al., 2009; Strober & Humphrey, 1987; Stunkard, 1997; Tozzi et al., 2003). The efficacy of individual CRT and group CRT have also been well documented for the adult population with AN (Davies et al., 2012; Dingemans et al., 2013; Leppanen et al., 2018; Lindvall Dahlgren & Rø, 2014; Tchanturia et al., 2017). Nevertheless, the literature on the efficacy of CRT for adolescents with AN within family interventions remains limited, often based on small sample sizes and predominantly composed of female participants (Cooper et al., 2024; Dahlgren et al., 2014; Lask & Roberts, 2015; Lock et al., 2018). This study seeks to address this gap by evaluating the effect of CRT on adolescents with AN as a complementary intervention in FBT. Second, unlike prior studies that primarily used self-report measures, questionnaires and neuropsychological and cognitive assessments to see changes in flexibility (Dahlgren & Stedal, 2017; Hagan et al., 2020; Herbrich et al., 2017; Tchanturia et al., 2007; Van Noort et al., 2016), we directly measure behavioral changes to assess how increased cognitive flexibility relates to better treatment outcomes - healthier food choices - in an experimental online grocery. This complements the other studies giving a first look at how this treatment can have a concrete impact on food choice. Finally, findings from this study will contribute to understanding how CRT can be integrated into standard AN treatment to improve outcomes, particularly by reducing post-treatment eating pathology. This research will also help inform best practices for CRT

implementation, providing further insights into whether the primary focus should be on adolescents or parents.

Literature Review

Anorexia nervosa (AN) is an eating disorder characterized by patients' low body weight measured with the body mass index (BMI), fear of weight gain, and a disturbed body image (Costandache et al., 2023). Anorexia can be categorized into two distinct patterns: one characterized by strict dietary restriction, and the other involving cycles of binge eating followed by purging (Costandache et al., 2023). AN, whatever its pattern, mostly appears towards the end of adolescence with the highest prevalence in adolescents between 15 and 19 years old (Costandache et al., 2023; Herpertz-Dahlmann, 2021; Van Eeden et al., 2021). Anorexia nervosa, known for having the highest mortality rate among all psychiatric disorders, exhibits a mortality increase of 5.6% each decade it persists, with over half of these deaths resulting from medical complications (Costandache et al., 2023; Couturier et al., 2020; Mehler & Brown, 2015). These characteristics underscore the seriousness and danger of the condition. Hence, early and effective treatment in adolescents is crucial to prevent severe medical problems, including death.

Treatment for anorexia is primarily focused on helping patients gain weight steadily by increasing the patients' caloric intake and decreasing their physical activity (Costandache et al., 2023; Patel et al., 2003). The aim is for the adolescent to go back to at least 90% of his or her ideal/expected body weight (IBW) calculated for the individual respecting his growth curve or for him/her to get over the diagnostic weight threshold, referring to the BMI (Loeb & Le Grange, 2009; Patel et al., 2003; Timko et al., 2021). With adolescents, the parents play a leading role in the renourishment process and should always be involved in treatment (Timko et al., 2021). Family-based treatment (FBT), a treatment in which the family is highly involved with the adolescent is recommended (Couturier et al., 2020).

Family-Based Therapy for AN

FBT is an intensive treatment lasting nine to twelve months in which parents are entrusted with overseeing the refeeding process, also involving a therapist and a physician focusing

on physical health (Couturier et al., 2013). FBT typically comprises 20 sessions in its manualized form, each 50 to 60 minutes, but has been shown to be also effective with a shorter duration (Dalle Grave et al., 2019; Loeb & Le Grange, 2009). FBT integrates techniques from a range of psychotherapeutic schools—narrative, systemic, and strategic—without adhering to any single therapeutic approach (Dalle Grave et al., 2019). The main goal being to assist the parents in weight restoration promotion and eating habits normalization, FBT contains three phases in which their role will gradually evolve (Egbert et al., 2023; Loeb & Le Grange, 2009). In the first of three phases of treatment, usually lasting three to four months, parents assume full responsibility for their child's eating, taking on roles akin to inpatient staff (Dalle Grave et al., 2019; Loeb & Le Grange, 2009). Guided by the therapist, parents hone their skills and strategies during family meals, aiming to encourage the child to consume slightly more than their initial willingness (Loeb & Le Grange, 2009). Control over food intake, as the treatment progresses and the adolescents' symptoms reduced, is later transitioned back to the adolescent during Phase II. Subsequently, Phase III of FBT addresses termination and broader adolescent developmental aspects such as creating a healthy adolescent-parent relationship (Dalle Grave et al., 2019; Loeb & Le Grange, 2009). In this phase, as weight has returned to normal and the eating disorder no longer dominates interactions, more general issues—such as autonomy and family boundaries—are also addressed (Dalle Grave et al., 2019). The parents play a role of supervision in those last two phases (Loeb & Le Grange, 2009).

This treatment is recommended and has been proven to be effective regardless of the different demographic, socioeconomic factors, and clinical variability (Datta et al., 2023). However, even when the target weight gain is achieved, some adolescents still exhibit significant levels of eating pathology up to 12 months after FBT (Egbert et al., 2023). This obstacle can be attributed to the neuropsychological profile of anorexia nervosa. Cognitive challenges perpetuate the chronicity of the disorder and contribute to poor treatment response (Lock & Le Grange, 2019; Tchanturia et al., 2017). Those difficulties can be seen through obsessive-compulsive and perseverative thinking (Lock & Le Grange, 2019). For example, patients may set up specific protocols on how to cut their food and decide which foods are "safe" or "unsafe" (Steinglass et al., 2006).

Parental Challenges in Family-Based Therapy

Moreover, some added difficulties can also play a role in the struggle for parents to follow family-based treatment. First, the disorder can take a toll on parents' mental health whether because they experience guilt about causing their children's disorder or because they're frightened by the symptoms (Dalle Grave et al., 2019). Nearly all parents (96%) indicated their emotional health was poorer than usual (Wilksch, 2024). This self-blame and fear may lead parents to become more lenient with the adolescent during FBT, resulting in the ED upholding (Wilksch, 2024). Second, patients with anorexia often have "fear foods" – usually foods high in calories and fat, that cause severe anxiety and avoidance responses (Cowdrey et al., 2013; Di Lodovico et al., 2023; Lloyd & Steinglass, 2018; Schebendach et al., 2019). Being confronted with these food items is important for treatment efficacy but often results in the child displaying extreme negative emotions, which can be difficult for parents to handle with regularity. Hence, parents could also allow food to be missed when fear food is involved to avoid upsetting their child. This hinders treatment efficacy (Wilksch, 2024). Third, the parents' poor understanding of AN can contribute to the self-blame associated with their child's condition and impede treatment by pushing them into inactivity or indecisiveness in their behaviors (Dalle Grave et al., 2019; Wilksch, 2024). Parental challenges can range from struggling to recognize symptoms and distinguish them from typical adolescent development to initially perceiving weight loss as positive and not comprehending why the child is reluctant to eat (Wilksch, 2024). The need to relearn what food is healthy for their child can be complicated. Patients are also often scared and confused because they rely on nonscientific sources to find information about healthy foods, which can exacerbate the parental struggle (Clemente-Suárez et al., 2023). The emphasis is on ensuring safe eating practices, even if it causes discomfort for the adolescent or if it is against what they think they know about healthy eating. Therefore, it is vital for parents to align their understanding and expectations with those of the clinician, which can be difficult, especially when the plan involves encouraging the child to eat foods they fear. (Honey et al., 2008). In the same way, they can have trouble changing their understanding of what constitutes healthy food, especially when it conflicts with widely accepted beliefs or common knowledge.

In sum, the stress associated with the condition, the prominence of the patient's fear foods, and the necessity for parents to relearn what constitutes healthy eating for their child all pose obstacles to treatment. Thus, the AN neuropsychological profile, particularly the restricted cognitive flexibility associated with it, is essential to consider during treatment in response to these difficulties.

Cognitive (In)flexibility in AN

A skill that greatly aids both adolescents and their families in the recovery process is the development of cognitive flexibility (Duriez et al., 2021). Cognitive flexibility is a thinking style in which set-shifting and central coherence contribute. Indeed, difficulty in set-shifting is characterized by rigid rules and behaviors, and a resistance to change, when weak central coherence concerns the way information processing is done, whether it is having a hard time seeing long-term goals or hyper-focusing on details (Timko et al., 2018) Cognitive flexibility encompasses the ability to transition between multiple tasks, operations, or entrenchment (Duriez et al., 2021). Moreover, diminished cognitive flexibility can be a factor in the sustained presence of maladaptive and rigid patterns of thinking and behaving which can be observed through difficulties redirecting attention, adapting promptly to new situations, and reacting to changing environmental requirements (Duriez et al., 2021; Timko et al., 2021). Unfortunately, difficulties in executive function, including cognitive flexibility are characteristic of both AN patients and their families (Timko et al., 2021). This can be explained by the executive function's heritability (Timko et al., 2021). Since all members of the family are affected by those inefficiencies, it is also important to acknowledge the impact of the family environment on the children's way of thinking and the efficacy of the treatment. Moreover, adolescents with eating disorders exhibit cognitive inflexibility and increased focus on details transdiagnostically, suggesting these traits are not merely a consequence of the disorder (Wang et al., 2021). This suggests that this inflexibility should be treated separately from the disease itself since it is not a sole consequence that would resolve when the disorder is treated.

Improved cognitive flexibility can also help the adolescent in recovery by reducing their resistance to the treatment. Indeed, cognitive style, particularly cognitive rigidity, has been identified as a factor that may influence treatment engagement and outcomes (Tchanturia et al., 2007). Additionally, poor cognitive flexibility is associated with sustained clinical symptoms in AN (Duriez et al., 2021). That can be seen, for example, through individuals with heightened cognitive rigidity struggling to modify familiar but maladaptive eating patterns necessary for recovery (Wang et al., 2021). Likewise, an intense focus on details may perpetuate a fixation on disorder-related rituals, such as calorie counting and body checking, which can hinder treatment progress. These rituals often reflect an excessive attention to minor details (Wang et al., 2021). Moreover, the adolescents' inclination to focus on information related specifically to high-caloric foods is attributed to their challenge in redirecting attention away from these items once identified (Smeets et al., 2008). However, for adolescents, the reductions in avoidance behaviors and increase in approach-based motivation linked to improvement in cognitive flexibility translates into more frequent social interactions and a heightened sensitivity to social rewards (Timko et al., 2021). In turn, this can enhance motivation for treatment and reduce these maintaining factors thereby promoting faster weight gain (Timko et al., 2021). The better adolescent's adherence to the treatment could also reduce tensions with parents and the stress they experience during the refeeding process. Briefly put, enhanced cognitive flexibility can help change the food-related mental patterns and routines which could have a direct impact on their behaviors.

Developing cognitive flexibility could help the parents better implement FBT and a better environment for their children's alimentation. In fact, mothers who experienced greater challenges in executive functioning consistently indicated lower adherence to recommended food-related parenting practices (Bauer et al., 2019). They also maintain less healthful home food environments, such as infrequent family meals, inconsistent mealtime schedules and structure, and using food to manage children's emotions (Bauer et al., 2019). On the other hand, promoting functioning skills in parents will improve their flexibility and therefore enhance their motivation to approach challenges rather than avoid them (Timko et al., 2021). This change increases their readiness to engage in exposure with their child, thereby reducing the likelihood of parents accommodating symptoms of

the eating disorder (Timko et al., 2021). Consequently, the difficulties encountered by parents during the refeeding process could be better managed, with better cognitive flexibility, to enable them to provide a sufficient and varied diet. To sum up, going through cognitive training can help reduce the adolescents' pushback behaviors and give more skills to parents to do what's needed during treatment. Therefore, knowing how it can be hard for families to follow treatment and even harder for those with set-shifting and central coherence inefficiencies, a specific treatment component such as Cognitive Remediation therapy, should focus on enhancing cognitive flexibility to help achieve and maintain the treatments' goals.

Cognitive Remediation Therapy

Cognitive Remediation therapy (CRT) encompasses various psychological interventions employing cognitive training exercises to enhance cognitive processes (Tchanturia et al., 2017). It aims to develop new strategies and thinking skills, promoting metacognition to facilitate behavioral changes in patients (Tchanturia et al., 2017). Typically, CRT involves ten sessions lasting 45 minutes each, scheduled once or twice weekly based on clinical resources and program design (Tchanturia et al., 2017). As mentioned before, adults and adolescents with anorexia nervosa (AN) commonly face challenges in two executive functioning areas: set-shifting— the ability to transition between different tasks, mental sets, or operations — and central coherence— integrating the information received within its broader context (Holliday et al., 2005; Lopez et al., 2009; Tchanturia et al., 2017). Therefore, CRT tailored for AN focuses on these aspects through exercises that promote cognitive flexibility and looking at the "bigger picture" instead of focusing on details, in a context that is not illness-specific. CRT serves as an adjunctive treatment as it is not sufficient as a treatment alone (Tchanturia et al., 2017; Timko et al., 2021). CRT interventions encourage individuals to recognize their cognitive styles, aiming to cultivate alternative thinking patterns applicable to daily life while also improving brain function (Tchanturia et al., 2017). CRT exercises are used to explore challenges such as specific routines that may pose issues (Tchanturia et al., 2014). Those exercises vary from sorting

tasks, and finding various routes on a map, to reversing sequences of numbers and letters while reflecting on the process of completing these tasks and learning new ways to complete them instead of using a perfection-based perspective (Timko et al., 2021). This adjunctive therapy was shown to have a positive impact on cognitive flexibility for adults, as well as for adolescents with AN (Timko et al., 2021). While CRT is flexible and has been used successfully for many psychopathologies, we still don't know exactly what relation it has with consumption behaviors in families with AN (Timko et al., 2021). Given the importance of refeeding in recovery, grocery shopping behaviors should be measured directly to see what changes happen when CRT is used as an adjunctive treatment.

Grocery behavior

Open Science Online Grocery (OSOG) is a website created by Howe and colleagues in 2022. It is a tool developed to analyze consumer behavior in a retail setting but has been adapted to support AN rehabilitation as well (Howe et al., 2022; Makara et al., 2023). The website replicates the layout of a typical online grocery store, showcasing around 10,000 American grocery products across various categories, including bread, beverages, frozen items, meat, and snack foods. The only exceptions - not found in American grocery stores - are items from Howe's own brand (Timko et al., 2021). Users do not make actual purchases or receive groceries, OSOG serves as a simulation, but the users can browse through the pages and add them to their cart (Howe et al., 2022). They can see information about the products when making their choices like product price, description, and nutritional values. The check-out process only indicates that they have finished their shopping. The store provides researchers with data on user purchasing behavior, including click patterns, time spent on different items, and details on which items are added to and removed from the cart during shopping. Starpoints are also attributed to products, which is an OSOG-specific overall measure of food healthiness—ranging from - 27 to nine (Howe et al., 2022).

Grocery shopping is a fundamental daily task that presents significant challenges for individuals with AN and their families (Koller & Berg, 2021; Makara et al., 2023). Moreover, grocery shopping plays a crucial role in shaping a patient's relationship with food during recovery (Clemente-Suárez et al., 2023). OSOG therefore provides valuable insights into changes in product selection, the diversity of this selection, caloric content, and micro- and macronutrients, making it a useful tool for monitoring progress. Given patients' tendency to avoid high-caloric foods and high-fat foods, and their limited product choices' diversity because of the fear foods (Cowdrey et al., 2013; Di Lodovico et al., 2023; Lloyd & Steinglass, 2018), OSOG offers a way to assess shifts in these behaviors. Additionally, AN patients often experience significant micronutrient deficiencies (Achamrah et al., 2017; Chiurazzi et al., 2017; Hadigan et al., 2000). Since results suggest that greater cognitive flexibility could be linked to a reduction in rigid cognitive and behavioral patterns in AN—improving both daily functioning and clinical severity—OSOG could serve as a direct measure of behavioral changes in parents related to food choices. Purchases in OSOG also act as an indirect measure of behavioral change in adolescents because parents' choices in OSOG are likely impacted by the adolescent's reduction in resistance and better acceptance of new foods in their alimentation.

Chapter 1
Methods

This study is part of a broader initiative named the Shifting Perspective Study initially conducted in the research arm of the Eating Disorder Assessment at Treatment Program (EDATP) at Children's Hospital of Philadelphia (CHOP) researching the most effective way to administer CRT to positively impact cognitive flexibility in both parents and adolescents. The study protocol of our research was approved by both the HEC Montréal Research Ethics Board (REB) and the CHOP Institutional Review Board. Deidentified data from patients and their parents, who had previously provided their children's and their own written consent for participation in the first study, were obtained through the CHOP team for use in this study. Participants for the initial study at CHOP were identified during hospitalization, outpatient assessments, or initial medical evaluations. The clinical team flagged potentially eligible adolescents and screened them for final eligibility upon their agreement. With this agreement, a baseline assessment was then scheduled. Participants included outpatient adolescents aged 12-18 years who were medically stable and diagnosed with Anorexia Nervosa (AN) according to DSM-5 criteria. Both biological parents' participation was needed for them to be included in the study. If they had siblings, they were also included in the treatment for at least four sessions (Timko et al., 2019).

The present study began in February 2024, employing the data from the first study that ran between May 2019 to 2020. To enhance external validity, CHOP members included individuals with common comorbidities of AN, such as anxiety, depression, and obsessive-compulsive disorder. Medication use was permitted and monitored throughout the study, except for atypical antipsychotics like Olanzapine, which are often used to aid weight gain and reduce rigidity in AN patients. Concurrent psychotherapy was also prohibited. A total of 54 families were selected to be part of the Shifting Perspectives study (Timko et al., 2021).

Recruitment began in August 2019, and participants underwent baseline assessments before being assigned to one of three groups using a covariate-adaptive randomization method (OxMaR, open-source software). This ensured an equal distribution of males

across the groups (Timko et al., 2021). The three groups were as follows: In the first group, only traditional FBT was received by the families for 15 sessions over six months. For the second group (CRTp), families received parent-focused CRT prior to undergoing the same FBT protocol as the first group. The last group had the same design layout, but with CRT focused on the adolescent (CRTa).

Procedure

For the three different conditions, assessment was taken at five different points: baseline (T1), four weeks (T2), 8-10 weeks (T3), 13-15 weeks (T4) and end of treatment (T5). Families and therapists were informed of their assigned treatment condition by the study coordinator after the baseline assessment. FBT was administered every week, during those six months, throughout the different time points – from T1 to T5. The two groups in CRT conditions (CRTa and CRTp) received their CRT sessions prior to every standard FBT treatment. The total professional contact time was identical across the CRT conditions, ensuring that observed differences between those groups were not attributable to additional treatment exposure. Families receiving CRT had more contact time with their therapist than those in the FBT condition only (Timko et al., 2021).

To ensure participant safety, adolescents were medically monitored throughout the study and required to allow providers to communicate amongst each other. Weight was measured at T1 (BMI before starting the treatment). In the case of a substantial weight decrease or lack of progress in the increase, a risk assessment was made. Reentry into the study was contingent upon medical stabilization, if the Medical Safety Officer determined that outpatient treatment was not appropriate anymore, the adolescent was then excluded from the study and referred for the necessary care (Timko et al., 2021).

The Open Science Online Grocery (OSOG) tool was employed at T1, T4, and T5 (see Appendix A) to evaluate parental food choices, focusing on caloric content, number of starpoints, diversity of products (number of different categories of food chosen), and the micro- and macronutrient following: fat, saturated fat, trans fat, poly fat, mono fat,

cholesterol, potassium, sodium, carbohydrates, fiber, sugar, and proteins. Participants completed additional tasks as part of the broader Shifting Perspectives protocol, although these will not be discussed in the current paper (Timko et al., 2021) (see Appendix A). We are interested in whether the CRT interventions (parent- or adolescent-focused) affect the kind of food that parents choose during the OSOG assessment. During this assessment, parents were asked to plan meals for three days and "purchase" necessary items using the OSOG app. The default version of OSOG, which mirrors a standard American online grocery store layout, was used without modifications such as budget constraints or front-of-package labels (see Appendix B). To control for potential differences in grocery decisions, the parent completing the task (mother or father) was noted for each assessment. The FBT-only group served as a control to account for improvements in set-shifting resulting from factors such as parental stress reduction, adolescent renourishment, or maturation. Additionally, this group serves as control for any practice effects from repeated assessments, such as in the OSOG test (Timko et al., 2021). Families lacking a recorded condition were automatically excluded before the analysis. Families without data following T1 for any of the parents were also excluded, as the analysis centered on the treatment's impact, which occurs after T1. To preserve external validity, we included families with missing data for one parent or one of the later stages (T4 or T5), as well as those with T1 data available for only one parent if they had a measure at T4 or T5. Data were missing at random, so we imputed data using data augmentation procedure (Timko et al., 2021). After excluding families with incomplete critical information and imputing the valid ones, the final sample comprised 40 families.

Participants

The average age of the adolescent in treatment was approximately 15 years (SD = 1.53, min = 12.56 years, max = 18.54 years). These adolescents had a mean Z-score BMI of -0.61 at T1 (SD = 0.76), with the lowest score at -2.21 and the highest at 0.91. The sample consisted of 33 girls and 7 boys, totaling 40 patients along with their families. Of these,

10 girls and 2 boys were randomly assigned to the FBT alone condition, 13 girls and 2 boys to the CRTp condition, and 10 girls and 3 boys to the CRTa condition.

The participants in our experiment were the parents of the adolescents in treatment. Specifically, the grocery shopping habits of 39 mothers and 39 fathers were observed, since for two of the families only the mother or the father did the task. 12 families were assigned to the FBT alone condition (12 mothers, and 11 father). 15 families were assigned to the CRTa condition (14 mothers, and 15 fathers). Finally, 13 families were assigned to the CRTp condition (13 mothers, and 13 father).

Measures

For each patient at each treatment stage, we calculated global metrics based on their final shopping cart. For example, we calculated the average calories, macronutrient content (e.g., protein, carbohydrates), and micronutrient content per serving across all foods in the cart at checkout. This enabled us to make comparisons accounting for variability in the number of grocery items selected.

Given the large number of potentially interesting outcome variables, we ran ANCOVAs (Type III) for each one of them to assess global effects and did post hoc tests for every variable that reached at least marginal significance. Specifically, we ran linear mixed models predicting the nutritional variable from treatment condition, treatment phase, and their interaction to explore those associations further. Because data included parental responses at three different time points, and in most cases both parents contributed to data, sometimes at the same time points, sometimes at different ones, we used a random intercept for family to account for within-family dependency. Although some parents contributed at multiple time points, the family sample (40 families) was not sufficient to support more complex nested random effects structures. Parent's sex (mother or father) was included as a fixed effect to control for mean differences between mothers and fathers. Other variables were also controlled for: age and sex of the patient, and baseline

BMI Z-score. This approach allowed us to model the hierarchical and partially nested structure of the data, despite the absence of traditional repeated measures per individual.

Subgroup analyses were subsequently conducted with pairwise comparisons to explore the interaction between the treatment phase and the condition, providing deeper insights into the dynamics of treatment impact under varying conditions. P-values were adjusted using Tukey method for comparing a family of three estimates, controlling for Type 1 error within each model's post hoc contrasts.

Chapter 2
Results

Preliminary analyses

Preliminary analyses were done using non-parametric analysis due to the small sample size within the groups. They revealed that the three groups were similar in terms of BMI, sex, age, and whether the participant's mother or father was doing the OSOG task ($p > .05$, see Table 1). This was consistent with expectations for sex, as participants were randomized into each condition to ensure an equal proportion of boys in each group (Timko et al., 2021). Nevertheless, in line with previous literature, the other variables (BMI, age and sex of the parent doing the task) were still included as covariates in the analysis, given their potential to influence the results.

Table 1: Intergroup difference by condition for Age, BMI, Patient's sex, and parent's sex for OSOG.

Variables	Test	Statistic	Degrees of freedom (df)	*P-Value*
Age (Year)	Krustal-Wallis	1.815	2	0.404
BMI Z-score	Krustal-Wallis	1.009	2	0.604
Patient's sex	Fisher's Test	-	-	0.874
Mom or dad - OSOG task	Fisher's Test	-	-	0.596

Note. The Fisher's exact test does not provide test statistics or degrees of freedom.

Analysis

For each dependent variable, we ran ANCOVAs (type III) predicting this outcome from the participant's treatment phase and condition, controlling for the patient's age, the sex of the parent who did the test, the patient's initial BMI, the patient's gender and the hierarchical structure of the data. In the absence of predefined hypotheses, we decided to explore all possible relationships of the variables measured with OSOG. Complete

ANCOVA results can be found in Appendix (see Tables 5 - 7). Given the exploratory nature of this study, no formal corrections were made for the multiple tests done, in order to keep a more comprehensive view of the potential relationships. In this case, it was more valuable to accept the risks of false positives to avoid overlooking potentially meaningful associations. However, the results of this study should be considered as preliminary hypotheses only, requiring further testing in confirmatory studies.

We observed a marginally significant treatment phase effect on Fat ($F(2, 187.60) = 2.73$, $p = .068$, $\eta_p^2 = .03$), Calories ($F(2, 188.54) = 2.98$, $p = .053$, $\eta_p^2 = .03$), Saturated Fat ($F(2, 188.27) = 2.72$, $p = .069$, $\eta_p^2 = .03$) and Starpoints ($F(2, 188.01) = 2.79$, $p = .064$, $\eta_p^2 = .03$), but they were not affected by condition, nor the interaction ($p > .05$, see Table 2).

Table 2: ANCOVA (type III) results predicting Calories, Fat, Saturated Fat, and Starpoints, from Condition, Treatment phase, and their interaction.

Predictors	Calories		Fat		Saturated_fat		Starpoints	
		F		*F*		*F*		*F*
Mother or father – doing OSOG task	-	1.75	-	0.70	-	0.46	-	0.35
Patient's sex	-	0.15	-	0.55	-	0.78	-	0.15
Age (year)	-	1.75	-	9.63**	-	10.92**	-	2.85 +
BMI (Z-score)	-	3.67+	-	1.88	-	2.82+	-	5.96*
Condition	0.67	1.14	0.16	0.46	0.21	0.24	0.41	1.08
Treatment phase	2.86+	2.98+	2.77 +	2.73+	2.74 +	2.72+	2.75+	2.79+
Condition X Treatment phase	0.88	0.90	0.40	0.37	0.21	0.25	0.41	0.40
Observations	234	234	234	234	234	234	234	234

+ $p < 0.10$, * $p < .05$, **$p<.01$, ***$p<.001$

The ANCOVA for sugar revealed nonsignificant main effects of the condition and the treatment phase ($p > .05$, see Table 3) and a marginally significant interaction effect ($F(4, 189.19) = 2.08$, $p = .086$, $\eta_p^2 = .04$).

The ANCOVA for carbohydrates also revealed nonsignificant main effects of the condition and the treatment phase ($p > .05$, see Table 3) and a marginally significant interaction effect ($F(4, 189.22) = 2.02$, $p = .093$, $\eta_p^2 = .04$).

Table 3: ANCOVA (type III) results predicting Carbohydrates and Sugar, from Condition, Treatment phase, and their interaction.

Predictors	Carbohydrates		Sugar	
	F		*F*	
Mother or father – doing OSOG task	-	0.46	-	1.09
Patient's sex	-	2.24	-	2.97+
Age (year)	-	0.42	-	0.12
BMI (Z-score)	-	1.57	-	0.095
Condition	2.32	1.57	2.69+	2.00
Treatmentphase	0.94	0.93	1.07	1.02
Condition X Treatment phase	1.97	2.02+	2.08+	2.08+
Observations	234	234	234	234

+ $p < 0.10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Diversity in products and other micro and macronutrients were not significantly affected by condition or treatment phase ($p > .05$, see Appendix: Tables 5 - 7).

For significant variables - fat, calories, saturated fat, starpoints, sugar, and carbohydrates - we then ran post-hoc comparisons using mixed linear models with the same covariables and controlling in the same way for the hierarchical effect in our data. We then did pairwise comparisons to see where the differences lay for significant results. Complete post-hoc comparisons with mixed linear models can be found in Table 4 and pairwise comparisons can be found in Appendix (see Tables 8 and 9).

We observed that on average, at T5, participants chose products with more calories (b = 11.66, SE = 5.72, p = .043) than at T1. No significant difference was found between T4 and T1 ($p > .05$, see Table 4).

On average, participants chose products with marginally more sugar and carbohydrates at T5 than at T1 (respectively b = 2.03, SE = 0.96, p = .036 and b = 2.60, SE = 1.23, p = .037). In line with ANCOVAs results, these effects were superseded by a significant

condition by treatment phase interactions for both carbohydrates (b = -3.67, SE = 1.71, p = .03) and sugar (b = -3.09, SE = 1.33, p = .02) (see Table 4).

We did not observe differences between the CRTp condition and the control condition in any of those variables or treatment phases ($p > .05$, see Table 4). Furthermore, we did not observe significant differences in fat, saturated fat, and starpoints in the mixed linear models for any treatment phase ($p > .05$, see Table 4).

Table 4: Linear Mixed Model results predicting Calories, Fat, Saturated Fat, Carbohydrates, sugar, and Starpoints, from condition, treatment phase, and their interaction

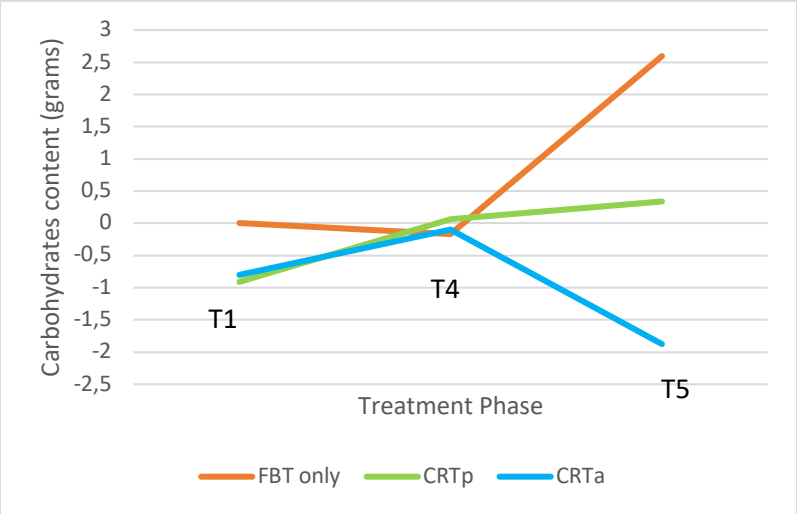
Predictors	Calories *B* (*SE*)		Fat *B* (*SE*)		Saturated Fat *B* (*SE*)		Carbohydrates *B* (*SE*)		Sugar *B* (*SE*)		Starpoints *B* (*SE*)	
Mom or dad - OSOG task	-	3.40 (2.57)	-	0.14 (0.17)	-	0.048 (0.072)	-	0.38 (0.55)	-	0.45 (0.43)	-	-0.15 (0.26)
Patient's Sex	-	-2.12 (5.44)	-	0.23 (0.31)	-	0.12 (0.14)	-	-1.50 (1.00)	-	-1.14 + (0.66)	-	-0.22 (0.57)
Age (Year)	-	-1.89 (1.43)	-	-0.26 ** (0.08)	-	-0.12 ** (0.038)	-	0.18 (0.27)	-	0.064 (0.19)	-	0.25 + (0.15)
BMI Z-score	-	5.47 + (2.85)	-	0.23 (0.17)	-	0.13 + (0.075)	-	0.69 (0.55)	-	0.12 (0.37)	-	-0.72 * (0.30)
CRTp	-2.77 (6.67)	-2.79 (6.70)	0.16 (0.42)	0.062 (0.40)	0.10 (0.19)	0.057 (0.18)	-1.12 (1.31)	-0.91 (1.33)	-0.25 (0.95)	-0.28 (0.96)	-0.06 (0.70)	-0.11 (0.69)
CRTa	-4.59 (6.86)	-5.70 (6.85)	-0.14 (0.43)	-0.34 (0.41)	0.041 (0.19)	-0.053 (0.18)	-1.04 (1.34)	-0.80 (1.36)	-0.35 (0.97)	-0.27 (0.98)	0.78 (0.72)	0.94 (0.71)
T4	3.23 (5.84)	3.86 (5.80)	0.39 (0.38)	0.47 (0.37)	0.22 (0.16)	0.26 (0.16)	-0.11 (1.24)	-0.17 (1.25)	0.22 (0.97)	0.14 (0.97)	-0.65 (0.60)	-0.76 (0.59)
T5	10.44 (5.76)	11.66* (5.72)	0.064 (0.37)	0.17 (0.37)	0.05 (0.16)	0.10 (0.16)	2.56 (1.23)	2.60* (1.23)	2.06 (0.95)	2.03* (0.96)	-0.42 (0.59)	-0.59 (0.58)
CRTp X T4	6.77 (7.80)	5.57 (7.75)	0.099 (0.5)	0.013 (0.50)	-0.013 (0.22)	-0.058 (0.22)	1.20 (1.66)	1.14 (1.67)	0.47 (1.29)	0.53 (1.30)	0.33 (0.80)	0.52 (0.79)
CRTa X T4	4.87 (8.00)	3.57 (7.96)	0.17 (0.52)	-0.004 (0.51)	-0.021 (0.22)	-0.11 (0.22)	0.75 (1.71)	0.87 (1.72)	0.11 (1.33)	0.22 (1.33)	-0.64 (0.82)	-0.44 (0.81)
CRTp X T5	-5.27 (7.71)	-6.20 (7.65)	-0.076 (0.50)	-0.14 (0.49)	-0.022 (0.22)	-0.052 (0.21)	-1.28 (1.65)	-1.35 (1.65)	-0.75 (1.28)	-0.74 (1.28)	0.24 (0.79)	0.37 (0.78)
CRTa X T5	-8.66 (7.98)	-9.86 (7.92)	0.46 (0.51)	0.36 (0.51)	0.13 (0.22)	0.076 (0.22)	-3.65* (1.70)	-3.67 * (1.71)	-3.139* (1.32)	-3.09 * (1.33)	-0.29 (0.81)	-0.11 (0.81)
Observations	234	234	234	234	234	234	234	234	234	234	234	234
Conditional R^2	0.236	0.274	0.199	0.226	0.238	0.270	0.176	0.187	0.110	0.123	0.253	0.300
Marginal R^2	0.042	0.099	0.028	0.119	0.025	0.138	0.064	0.083	0.066	0.083	0.029	0.114

Notes. For treatment phase, T1 (baseline) is specified as the default. For condition, FBT alone (control) is specified as the default.

+ $p < 0.10$, * $p < .05$, ** $p < .01$, *** $p < .001$

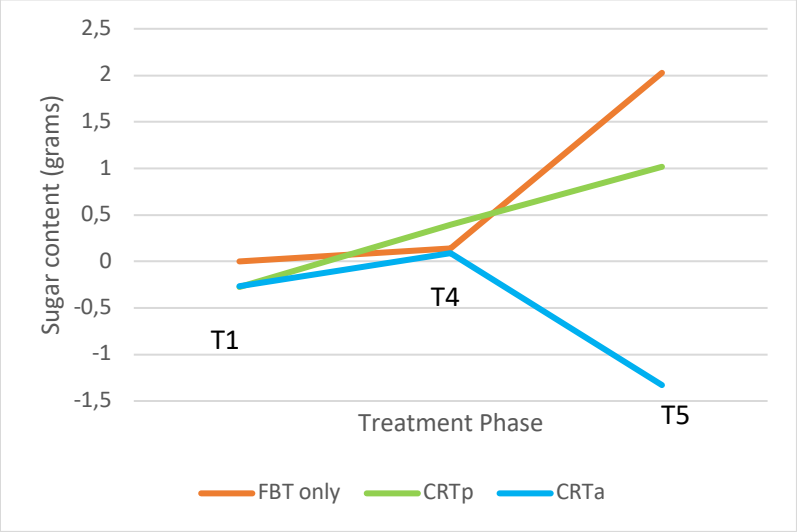
Specifically, we observed that at time 5, participants in the CRTa condition purchased groceries with fewer carbohydrates per serving (M = 15.90, SE = 0.98) than participants in the FBT condition (M = 20.30, SE = 1.07), $t(123) = 3.21$, $p = .0049$ (see Figure 1). There was no difference between the conditions at baseline nor at time 4 ($p > .05$, see Appendix: Table 8).

Figure 1: Carbohydrate contents through time in different condition groups.



Similarly, at time 5, participants in the CRTa condition purchased groceries with fewer grams of sugar per serving (M = 6.46, SE = 0.71) than participants in the FBT condition (M = 9.82, SE = 0.77), $t(149) = 3.33$, $p = .0031$ (see Figure 2). There was no difference between the conditions at baseline or at time 4 ($p > .05$, see Appendix: Table 9).

Figure 2: Sugar contents through time in different condition groups.



Additionally, at time 5, participants in the CRTp (M = 8.81, SE = 0.67) condition purchase groceries with higher grams of sugar per serving compared to CRTa (M = 6.46, SE = 0.71), $t(158) = 2.52$, $p = .034$ (see Figure 2 and Appendix: Table 9).

Chapter 3
Discussion

Only participants' sugar and carbohydrate purchasing were significantly affected by treatment conditions. Parents of teens who completed CRT training (i.e., CRTa) chose products containing less sugar and less carbohydrates than the parents in the FBT-only control condition.

It is difficult to interpret whether this means the CRT intervention improved or worsened parents purchasing behaviors. On the one hand, a decrease in sugars and carbohydrates may reflect a turn away from low-fat foods. Since patients with AN often include more fruits and vegetables, which contain high levels of carbohydrates and sugar, in their diet to replace or avoid fear foods (Buck et al., 2022; Pereira et al., 2022; Setnick, 2010), a decrease in sugar and carbohydrates could be associated with a better balance in their consumption and less pressure to the parents to buy those specific products. On the other hand, patients with AN often consume products with more artificial sweeteners, instead of real sugar, and caffeine to mask hunger or to control their weight, for example (Marino et al., 2009; Moore, 2015; Setnick, 2010). This would mean buying less sugar and carbs could be associated with a worse balance in the adolescent consumption after receiving CRTa and more pressure on the parents to buy products filling those "patterns" like buying products containing saccharin and aspartame instead of sugar (Marino et al., 2009). Given that we do not see commensurate increase in the diversity of food categories and subcategories purchased or fat—both of which would indicate a better balance in consumption—we suggest these findings reflect a less strict adherence to treatment.

This worsening may be explained by the fact that the parents (i.e., the participants shopping in the store) did not get treatment for their cognitive flexibility. Because cognitive flexibility is heritable, it is likely that these parents are also inflexible. Hence, bettering only the children's cognitive flexibility could be inefficient because product choices in the house would still be limited and in part determined by the parents. Indeed, parents would retain inflexible cognitions and behaviors and have difficulty relearning what is truly healthy for their children in recovery, as well as following treatment (Timko

et al., 2021). This persisting inflexibility could make them more conservative during grocery shopping when their adolescent (as a result of CRT) begins to challenge established routines. This mismatch in cognitive flexibility may lead to poorer food choices than in families receiving FBT alone (where neither party's flexibility improves), as FBT encourages parents to expose their child to fear foods even when they resist. However, for macronutrients like carbohydrates and sugar which are easily identifiable, if parents have not updated their understanding of what constitutes healthy eating and they stay resistant to changes, they may interpret their child's new preferences as signs of relapse or persisting symptoms rather than progress. This could encourage parents to push back even more against their child's demands, ultimately leading to more rigid—and potentially less appropriate—purchasing decisions than if no flexibility training had occurred at all.

Families receiving CRT focused on adolescents also chose products containing less sugar than the families in the condition receiving CRT focused on parents. These results suggest that indeed, conflict could arise when only adolescents receive cognitive flexibility training. Moreover, it suggests that since parents are the ones choosing the products, giving the training only to them could be more efficient in terms of avoiding persistent unhealthy consumption behaviors, while it doesn't mean children would eat the products bought.

However, the results also showed that families where CRT was focused on parents did not differ from the families receiving only FBT for any of the studied variables. Those results suggest that while it is better than enhancing only adolescent flexibility, enhancing only parental cognitive flexibility is not necessarily associated with direct changes in consumption behaviors either. We suggest that enhancing only the parental cognitive flexibility, while in theory helping to choose better products, is perhaps undermined by the adolescents' high reluctance to change their eating habits, creating discordance in the family. Indeed, parents wanting to change routines or consumption habits without the adolescent being on the same page could create conflicts with parents and cause stress associated with meal choices. This would then hinder their new competencies and interfere with the progress in product choices. However, it is known that increasing

parental flexibility can serve as a model for adolescents, helping them develop greater flexibility themselves (Timko et al., 2021). Therefore, it is possible that, over time, improvements might have emerged in this group as both parental and adolescent flexibility would have evolved. These results raise hypotheses about a possible intra-family cognitive dissonance that would need further investigation in ulterior studies.

These results also prompt questions regarding the behavioral differences related to carbohydrate types. In our analysis, the variable "carbohydrates" encompassed both simple and complex carbohydrates. That said, as mentioned before, cognitive flexibility treatment also seemed to be affecting simple carbohydrates – commonly referred to as sugar – which were also analyzed as a separate variable in this study. Therefore, it may be valuable to consider subtypes of carbohydrates in future research given that only sugar was associated with worse outcomes in the CRTa group, while general carbohydrates were not. This suggests that while those macronutrients are related, there may be meaningful distinctions in the way carbohydrate subtypes, like fiber or sugar, relate to changes in cognitive flexibility.

No other relationship was found between consumption behaviors and other variables in our analysis. Those results suggest that enhancing cognitive flexibility whether only in parents or in adolescents is not associated directly with diversity, calories, or level of other macro and micronutrients of chosen products. From a behavioral point of view, giving CRT only to the adolescent or to the parent seems to not be useful for improving product choice and product diversity during grocery shopping, and may even be counterproductive in some cases. We suggest that there is a possibility in which offering adjunctive CRT to both parents and adolescents simultaneously may improve consumption behaviors.

It is also possible that CRT provides little benefit on top of the benefits provided by FBT for certain variables. The first focus of FBT is refeeding and enhancing weight, with a therapeutic approach focusing on reintroducing fear foods in their diet, which are generally related to high-caloric and high-fat foods (Cowdrey et al., 2013; Di Lodovico et al., 2023; Lloyd & Steinglass, 2018; Rienecke & Le Grange, 2022; Timko et al., 2021). It is possible that FBT alone leads to behavioral changes for these nutrients, which may

lead to a ceiling effect explaining the null effects of supplementary CRT. If so, this may explain why CRT only affects secondary nutrients like sugar and carbohydrates, which are not the sole focus of FBT treatment.

Major contributions:

First, this study makes a significant contribution to the existing literature on AN treatment by introducing a new perspective. While fear foods in AN patients have been widely studied, and FBT is well implemented, routines are still hard to change for patients and symptoms persist, which shows a gap in our understanding of the variables that maintain the disorder. Cognitive flexibility appears to be a promising avenue to help diminish those remaining symptoms, but it remains unclear how Cognitive Remediation Therapy (CRT) impacts approach-avoidance behaviors, for example in relation to fear foods. This study provides preliminary evidence of the effectiveness of CRT treatments for dietary changes.

The current findings provide an important start to identifying meaningful variables in a behavioral context that should be studied in relation to CRT. Indeed, in exploring the associations between types of food choices and changes in cognitive flexibility post-treatment, this research shed first light on the possible directions of remaining symptoms and on areas that may have been neglected in traditional treatment approaches. For example, fat and calories are the most mentioned variables in the literature when looking at AN treatment. As mentioned before, there is a possibility that FBT treatment focused so much on these variables that they were already accounted for with or without CRT as an adjunctive treatment. This would explain why parents choose more calories at the end of the treatment regardless of the condition they were in. Identifying variables related to remaining symptoms and consumption behaviors offers valuable insights to future research and could help implement more effective treatment strategies for this challenging and dangerous disorder.

This study also highlights the importance of incorporating behavioral measures alongside the psychological assessments typically used when studying phenomenon related to

alimentation and disordered eating. Our findings support the notion that cognitive treatment does not necessarily translate directly into concrete positive changes in behaviors and daily life habits. Furthermore, this research also underscores current knowledge about the critical role parents play in disordered eating treatments and the meaningful impact they can have on the therapeutic process' course. While also adding nuances to this statement, by showing ways in which hardships or incongruence in the relation child-parents could be potentially harmful to treatment outcomes.

From a more practical standpoint, this study contributes to the growing body of knowledge on CRT best practices, by formulating hypotheses on how to implement it more effectively to reduce lasting symptoms. Furthermore, this study put into practice OSOG and demonstrated how a marketing tool can be adapted and used in clinical settings to assess behavioral changes. This deepens the understanding we have of how this kind of tool could help families with a member suffering from AN, particularly in challenging tasks like grocery shopping.

Limitations

First, as mentioned before, although we did control for Type I error within each model's post hoc contrasts using Tukey-adjusted pairwise comparisons, it is crucial to note that statistics were not adjusted for multiple-comparisons across models, despite the 14 variables being studied. This could influence the results by increasing the possibility of Type I errors (i.e. identifying associations due to random occurrence). This study still gives an interesting perspective while identifying relationships that could warrant further investigation but, knowing this, the findings should be interpreted with caution, and formal hypotheses ought to be confirmed in additional studies. Moreover, now that we have a clearer understanding of which variables would be interesting to focus on, multivariate analyses should be employed in the future with larger sample sizes to explore how those variables are related to each other and to cognitive flexibility enhancement more thoroughly while considering their relationship to each other – such as sugar and carbohydrates which are correlated.

Furthermore, while direct behaviors are measured in parents, the adolescent's behavioral component related to cognitive flexibility is mostly indirect, through resistance to parental choices and change. As a result, it is possible that since the OSOG tool only directly measures parental behaviors during grocery shopping, the results may not fully represent the actual consumption of those products at home. Indeed, it is plausible that enhancement in cognitive flexibility was associated with actual adolescents' eating habits at home even if grocery products themselves remained unchanged. This aspect – which also applies to diversity in the products - was not captured in our study. Along the same lines, it is possible that parents knowing they were being evaluated altered their purchase behaviors all through the study compared to a typical grocery shopping.

Given that grocery shopping is often a challenging task for these families, it is possible that using this particular task immediately after treatment may be too demanding to assess an actual behavioral change. Indeed, there's a possibility that doing this task in that time frame would not have allowed them enough time to integrate changes in their routines, particularly since they may not have had the opportunity to ease into these changes with easier tasks at first. Therefore, we suggest that future studies measure easier behavioral consumption tasks at first or evaluate the same behaviors later in time, after the final treatment session, to potentially capture more meaningful changes.

Another important consideration pertains to the recruitment protocol. We had no control over this process since our study used secondary data, but it is important to consider that self-selection biases may have influenced our sample. Indeed, participants were all recruited within a medical context, and it is possible that the families who decided to participate or to complete the study were families already more flexible in their behaviors. That is, especially knowing that difficulties in set-shifting are related to unwillingness to change (Timko et al., 2018). Thus, it is possible that this group of families benefitted less from cognitive flexibility training, than the standard population of families in treatment, as they may have been already at a good point in their consumption behaviors. This is coherent with the fact that families with more favorable behaviors would be more willing to be tested about those behaviors. However, we could not verify their initial flexibility, as we do not have access to those pre-study data.

Along the same lines, we didn't have access to cognitive flexibility scores throughout the study. Although the literature suggests that CRT would enhance cognitive flexibility, there is still a possibility that the addition of CRT to the treatment did not significantly enhance cognitive flexibility for our participants. This also means we are unable to determine whether the observed behavioral changes were directly associated with a change in cognitive flexibility. While CRT as an adjunctive treatment appears to be associated with some changes in the behaviors, the underlying process still requires further confirmation.

Futures directions:

This study provides a valuable foundation for research on the behavioral outcomes of cognitive flexibility interventions in eating disorder treatment. That being said, the results of this study are limited due to previously described limitations and should be confirmed through further studies.

Since we saw that some variables studied here are related, like carbohydrates and sugar, it would be insightful to combine the most interesting variables identified in this study to examine if the associations found would change when we consider their effects altogether.

Moreover, future studies could incorporate a direct measure of the adolescent's food consumption, allowing researchers to observe direct behavioral changes not only in parents but also in adolescents, whose behaviors were only measured indirectly in this study. This could help confirm our findings and provide deeper insights into consumption-related behavioral changes.

Another important avenue for future research would be to consider cognitive flexibility at the baseline and compare the outcomes of groups with different levels of cognitive flexibility at T1 after receiving CRT. This could help deepen our understanding of when and with whom it would be most appropriate to use CRT as an adjunctive treatment.

Lastly, it would be valuable to explore whether modifying the interface of OSOG by showing more information about pertinent variables could help parents make better choices. Enhancing the tool's functionality could provide good insight into how to better help those families with hard daily-life behaviors such as grocery shopping.

Conclusion

In summary, this study examined how interventions aiming to change cognitive flexibility deficits associated with AN influence daily-life activities, particularly grocery shopping in families. The results suggest that CRT does not necessarily translate to desirable behavioral changes, perhaps because offering CRT only to one member of the family could be creating conflict and be counterproductive. These findings indicate that more work examining the behavioral outcomes of ED treatment, including CRT is necessary to ensure that cognitive changes are reflected in behavioral outcomes.

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Table 5

Table 5 : ANCOVA (type III) results predicting Categories, Subcategories, Caloric Density and Proteins, from Condition, Treatment phase and their interaction.

Predictors	Categories	F	Subcategories	F	Caloric density	F	Proteins	F
Mother or father – doing OSOG task	-	1.56	-	4.91*	-	0.30	-	0.72
Patient's sex	-	4.75*	-	1.42	-	0.12	-	0.15
Age (year)	-	0.06	-	1.24	-	7.19**	-	0.0003
BMI (z-score)	-	0.17	-	0.17	-	1.34	-	1.57
Condition	0.19	0.17	0.36	0.48	0.06	0.40	0.41	0.36
Treatmentphase	0.21	0.20	0.12	0.17	1.36	1.32	1.05	1.03
Condition X Treatment phase	0.46	0.47	0.18	0.15	0.78	0.68	0.71	0.67
Observations	234	234	234	234	234	234	234	234

+ $p < 0.10$, * $p < .05$, **$p<.01$, ***$p<.001$

Table 6

Table 6 : ANCOVA (type III) results predicting Cholesterol, Sodium, Potassium and Fibers, from Condition, Treatment phase and their interaction.

Predictors	Cholesterol		Sodium		Potassium		Fiber	
		F		F		F		F
Mother or father – doing OSOG task	-	1.67	-	1.38	-	0.11	-	0.064
Patient's sex	-	5.23*	-	0.17	-	1.14	-	0.57
Age (year)	-	0.91	-	1.45	-	0.92	-	0.44
BMI (z-score)	-	1.54	-	9.82**	-	0.47	-	0.077
Condition	0.35	0.63	0.47	0.23	1.04	0.57	1.41	1.62
Treatmentphase	0.13	0.16	2.09	1.74	0.079	0.12	1.44	1.40
Condition X Treatment phase	0.88	0.88	0.43	0.35	1.36	1.25	0.66	0.62
Observations	234	234	234	234	234	234	234	234

+ $p < 0.10$, * $p < .05$, ** $p<.01$, *** $p<.001$

Table 7

Table 7 : ANCOVA (type III) results predicting Trans fat, polysaturated fat and monosaturated fat, from Condition, Treatment phase and their interaction controlling for mom or dad (OSOG task), patient's sex, Age and BMI Z- score.

Predictors	Trans Fat		Poly-saturated fat		Mono-saturated fat	
	F		F		F	
Mother or father – doing OSOG task	-	0.93	-	1.36	-	2.01
Patient's sex	-	0.58	-	0.10	-	0.65
Age (year)	-	0.40	-	0.36	-	0.58
BMI (z-score)	-	3.34+	-	0.16	-	3.76 +
Condition	0.88	0.70	0.94	0.60	0.80	1.07
Treatmentphase	0.80	0.66	1.20	1.17	1.93	1.84
Condition X Treatment phase	0.86	0.90	0.68	0.68	0.17	0.15
Observations	234	234	234	234	234	234

+ $p < 0.10$, * $p < .05$, **$p<.01$, ***$p<.001$

Table 8 – Post hoc Carbohydrates

Table 8 : Post-hoc test results for carbohydrate content: Comparison of conditions between treatment phases.

```
Treatmentphase = 1:
 Condition emmean    SE    df lower.CL upper.CL
         1   17.7 1.050  99.7     15.7     19.8
         2   16.8 0.943 103.6     15.0     18.7
         3   16.9 0.964 111.9     15.0     18.8

Treatmentphase = 4:
 Condition emmean    SE    df lower.CL upper.CL
         1   17.6 1.100 110.0     15.4     19.7
         2   17.8 0.946 103.2     15.9     19.7
         3   17.6 0.970 110.7     15.7     19.6

Treatmentphase = 5:
 Condition emmean    SE    df lower.CL upper.CL
         1   20.3 1.070 104.8     18.2     22.5
         2   18.1 0.931 105.0     16.2     19.9
         3   15.9 0.979 114.5     13.9     17.8

Treatmentphase = 1:
 contrast                estimate   SE  df t.ratio p.value
 Condition1 - Condition2    0.909 1.33 121   0.681  0.7747
 Condition1 - Condition3    0.801 1.36 120   0.587  0.8273
 Condition2 - Condition3   -0.109 1.28 127  -0.085  0.9961

Treatmentphase = 4:
 contrast                estimate   SE  df t.ratio p.value
 Condition1 - Condition2   -0.227 1.35 127  -0.168  0.9845
 Condition1 - Condition3   -0.070 1.42 120  -0.049  0.9987
 Condition2 - Condition3    0.157 1.29 126   0.122  0.9919

Treatmentphase = 5:
 contrast                estimate   SE  df t.ratio p.value
 Condition1 - Condition2    2.258 1.33 126   1.702  0.2086
 Condition1 - Condition3    4.472 1.39 123   3.206  0.0049
 Condition2 - Condition3    2.214 1.28 133   1.725  0.1995
```

Table 9 – Post hoc Sugar

Table 9 : Post-hoc test results for sugar content: Comparison of conditions between treatment phases.

Treatmentphase = 1:

Condition	emmean	SE	df	lower.CL	upper.CL
1	7.79	0.748	121	6.31	9.27
2	7.52	0.676	128	6.18	8.86
3	7.53	0.694	138	6.15	8.90

Treatmentphase = 4:

Condition	emmean	SE	df	lower.CL	upper.CL
1	7.93	0.790	133	6.37	9.50
2	8.19	0.678	127	6.85	9.53
3	7.88	0.697	137	6.50	9.26

Treatmentphase = 5:

Condition	emmean	SE	df	lower.CL	upper.CL
1	9.82	0.767	128	8.30	11.34
2	8.81	0.667	129	7.49	10.13
3	6.46	0.705	141	5.07	7.86

Treatmentphase = 1:

contrast	estimate	SE	df	t.ratio	p.value
Condition1 - Condition2	0.27496	0.964	147	0.285	0.9562
Condition1 - Condition3	0.26824	0.985	146	0.272	0.9599
Condition2 - Condition3	-0.00672	0.928	153	-0.007	1.0000

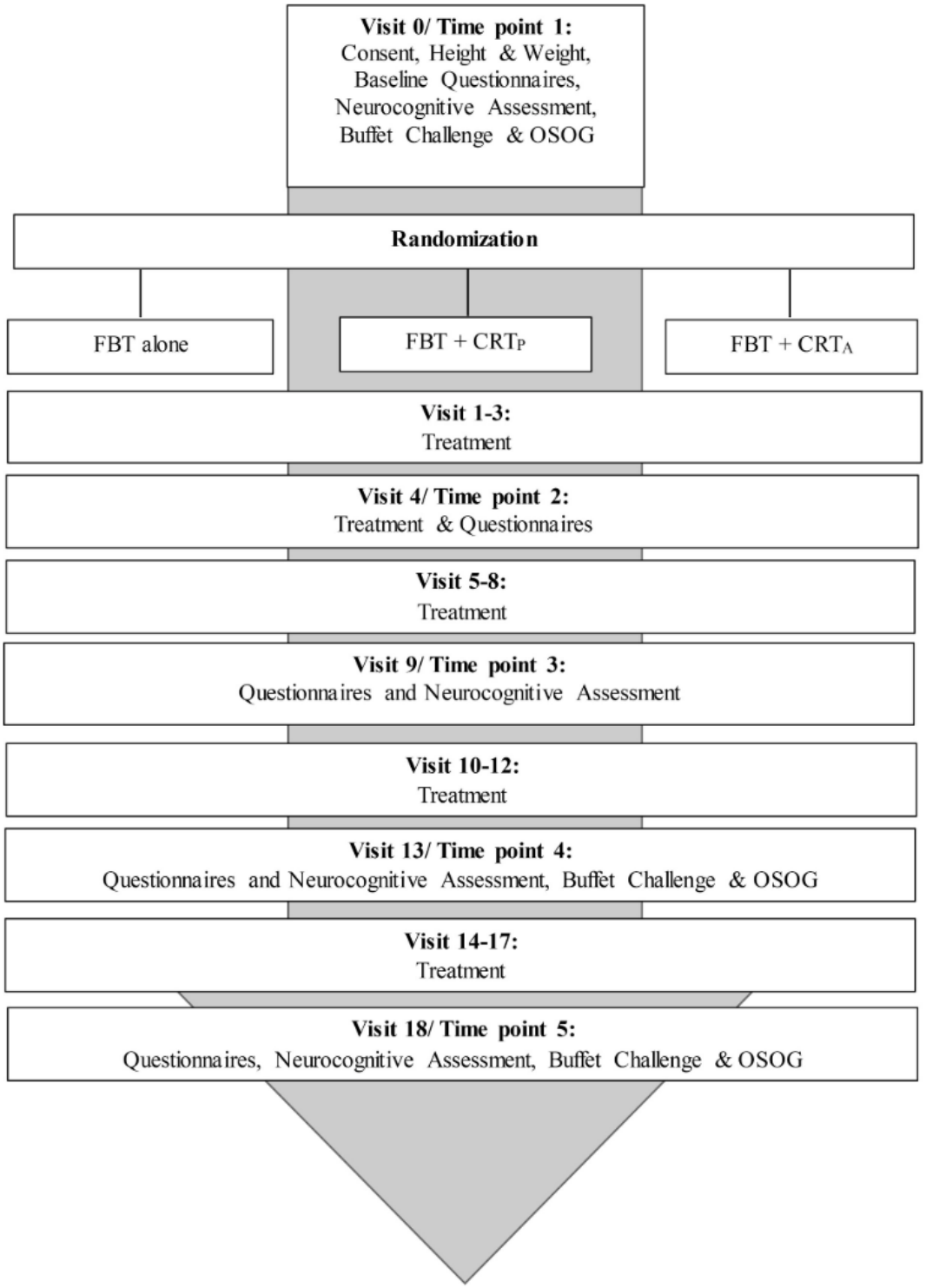
Treatmentphase = 4:

contrast	estimate	SE	df	t.ratio	p.value
Condition1 - Condition2	-0.25577	0.978	154	-0.261	0.9630
Condition1 - Condition3	0.04979	1.030	145	0.048	0.9987
Condition2 - Condition3	0.30556	0.934	152	0.327	0.9427

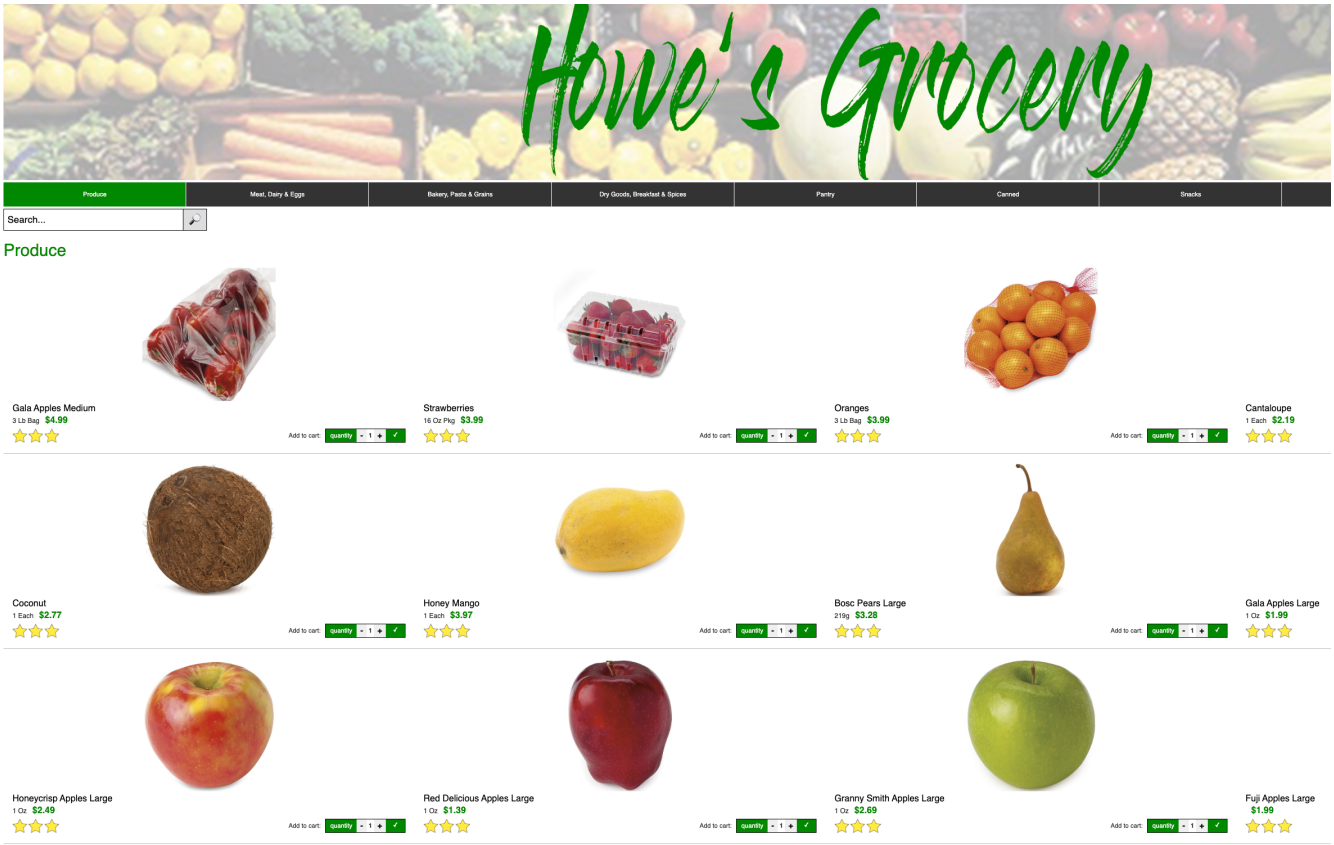
Treatmentphase = 5:

contrast	estimate	SE	df	t.ratio	p.value
Condition1 - Condition2	1.01041	0.961	153	1.052	0.5455
Condition1 - Condition3	3.35596	1.010	149	3.328	0.0031
Condition2 - Condition3	2.34555	0.932	158	2.518	0.0340

Appendix A – Original study protocol model



Appendix B – OSOG Platform



Appendix C – CER approval of the study

HEC MONTRÉAL

Comité d'éthique de la recherche

December 03, 2024

To the attention of: Gabrielle Fortin

Re: Ethics approval of your research project

Project No.: 2025-6221
Title of research project: Consumption behavior and cognitive flexibility in families of adolescents with anorexia nervosa.

Dear Gabrielle Fortin,

Your research project has been evaluated in accordance with ethical conduct for research involving human subjects by the Research Ethics Board (REB) of HEC Montréal.

A Certificate of Ethics Approval attesting that your research complies with HEC Montréal's *Policy on Ethical Conduct for Research Involving Humans* has been issued, effective December 03, 2024. This certificate is **valid until December 01, 2025.**

Please note that you are required to renew your ethics approval before your certificate expires using Form *F7 – Annual Renewal*. You will receive an automatic reminder by email a few weeks before your certificate expires.

If any changes are made to your project before the certificate expires, you must complete *F8 – Project Modification* and obtain REB approval before implementing those changes. If your project is completed before the certificate expires, you must complete Form *F9 – Termination of Project* or *F9a – Termination of Student Project*, as applicable.

Under the *Policy on Ethical Conduct for Research Involving Humans*, researchers are responsible for ensuring that their research projects maintain ethics approval for the entire duration of the research work, and for informing the REB of its completion. In addition, any significant changes to the project must be submitted to the REB for approval before they are implemented.

You may now begin the data collection for which you obtained this certificate.

We wish you every success in your research.

REB of HEC Montréal

Appendix C – suite

HEC MONTRÉAL

Comité d'éthique de la recherche

CERTIFICATE OF ETHICS APPROVAL

This is to confirm that the research project described below has been evaluated in accordance with ethical conduct for research involving human subjects, and that it meets the requirements of our policy on that subject.

Project No.: 2025-6221

Title of research project: Consumption behavior and cognitive flexibility in families of adolescents with anorexia nervosa.

Principal investigator: Gabrielle Fortin

Director: Holly Howe

Co-researchers: Alix Timko, C.

Date of project approval: December 03, 2024
Effective date of certificate: December 03, 2024
Expiry date of certificate: December 01, 2025

Maurice Lemelin
Président
CER de HEC Montréal

Signé le 2024-12-03 à 15:42

Appendix D – AI declaration of use

As part of this project creation, I used artificial intelligence as an assistance tool for:

Translation and correction

AI was used to help review and improve quality of my translation. This step was used to guarantee quality of my sentence, while keeping my own ideas and way of writing.

R coding

AI was also used to help troubleshoot code in R when doing the analysis of my data.

Limits and responsibilities:

Ideas and final choices were mine entirely. No ideas were generated by AI, it was used exclusively as a support tool and not as a substitute for my personal reasoning or critical analysis.

OpenAI. (2025). ChatGPT (version GPT-4.0). [Can you correct grammar and make this clearer?]. https://chatgpt.com/

OpenAI. (2025). ChatGPT (version GPT-4.0). [Why is this code not working?]. https://chatgpt.com/